THE AERIAL TRAVERSE

An Application of Aerial Photography to Geographic Studies

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Because of the comprehensive view of the landscape which it affords, the airplane makes possible a new mode of attack on geographical problems, especially on those which deal with any aspects of the distribution and special interrelations of geographic features. The observer in a plane is not limited as is the ground observer who depends on natural elevations for his outlook points. Whether the topography is flat or mountainous, altitudes may be chosen such that considerable areas can be included in a single view, and the point of view can be changed at will—a great advantage. The pattern of land utilization, the distribution of cultivated land with respect to topography, control of communication routes by topography, distribution of vegetation with respect to topography or to geological features, and numerous other aspects of geographical problems may be seen and studied in their mutual relations better from an airplane than in any other way. Photography preserves a permanent record of such information that can later be studied at leisure, and can be supplemented as necessary by work on the ground, provided the location of each of the pictures is definitely known.

The extensive network of airlines in the United States makes it possible for the geographer to select routes covering almost any of the principal types of geographic environment, so that in order to make extensive use of this new method of geographic study and recording it is generally not necessary to charter a special plane, although it may be desirable for special studies of particular areas.

LOCATION

As already suggested, for rigorous scientific work it is necessary that the exact, or nearly exact, location of each picture be known, so that the features which it shows can be properly placed on a map and so that the district may be visited later on the ground if necessary for proper interpretation of features shown on the photographs.

During flight, the procedure necessary for locating the pictures is to record the time when each picture is taken to the nearest practical division of a minute—generally to the nearest quarter minute—and also to record the time of the passage of the plane over or past objects such as towns, railroads, or rivers, which can be recognized on the small-scale map which the observer carries with him in the plane.

Such a map should be on a scale of about eight to twelve miles per inch. The writer has found the most satisfactory maps for this purpose to be the State maps on those scales, which are available in almost any bookstore. Those maps commonly show cities and towns, railroads, and drainage—the features most readily recognized by an observer in a plane. Highways are not satisfactory because in most regions they are too numerous and are not readily identified. Consequently, automobile highway maps of the states are not satisfactory.

The approximate line of flight along a regular air route is, of course, known in advance. The observer marks in pencil a straight line along the proposed route which is helpful in enabling him to find quickly on the map objects over which he passes. It is also useful to prepare in advance on a 3 x 5 card a scale in minutes corresponding to the scale of the map used. For example, if the plane is flying at three miles per minute, which is perhaps a little faster than the ordinary cruising speed of the modern transports, the scale would show distances according to the scale of the map traversed in 1, 2, 3, 4, 5, and so forth, minutes. If one passes over clouds, or for any other reason loses contact with known ground features long enough to become doubtful of his location, the approximate location can then be determined quickly by applying to the map such a scale and measuring along the flight line from the last identified point.

The observer carries in the plane, in addition to the map and the scale just described, a convenient notebook in which to record the film roll number of each picture, a brief description sufficient to identify the subject, and the time the picture is taken. If pictures are taken in rapid succession, it may be possible to record only the time, but the picture itself will generally supply the needed information later.

With a little practice, the observer, knowing his approximate height (which can always be obtained from the pilot) learns to judge closely enough for location purposes the distance to objects on the ground, such as towns, bends in rivers, etc., so that it is not necessary to pass directly over them in order to use them for location.

PHOTOGRAPHY

In modern planes it is necessary that all photographs be taken through the plane window. The window, being made of laminated, shatter-proof glass, must of course introduce some distortion and blurring of the image, but so little that it is scarcely recognizable on the photographs. Disturbed air from the exhaust of the motor, which is sometimes in the line of vision for part of the photograph, causes more serious blurring, but even this is seldom recognizable. Even dirt on the windows, unless excessive, does not seem to cause difficulty. Satisfactory pictures have been obtained through the windows of a flying boat noticeably clouded with evaporated ocean spray. In photographing through a plane window, however, it is necessary that the camera be held as close to the glass as practicable without touching. To avoid the effects of vibration, neither the camera nor the operator's hands should be in rigid contact with the plane. If the camera is held too far from the glass, reflections of objects in the plane may cause trouble.

The Camera:

Any good camera may be used, but there are many advantages in using one of the "miniature" type cameras using 35 mm. film. One of the great advantages is that such cameras can be operated very quickly and easily, so that pictures may be taken in rapid succession, and another is that the number of the picture on the roll is shown on the exposure counter, so that each picture can be referred to by number. A third important advantage is that about 35 pictures may be taken before it is necessary to change rolls. With such a camera, enlargements to 5 x 7 inches have been secured that are microscopic in detail, that is, objects invisible to the naked eye on the enlargement can be seen with a hand lens.

Film:

To permit satisfactory enlargements, a fine-grained film is desirable. It is essential that the film have an emulsion yielding relatively high contrast. Ultra rapid film should be avoided because it tends to be flat and lacking in contrast, and to have coarse grain. A rapid emulsion speed is not necessary or desirable. Among Eastman films, Background-X (a commercial film prepared for the motion picture industry and not available in most photographic stores) has been found highly satisfactory. It is fine-grained, and has relatively strong contrast. Eastman Panatomic-X is satisfactory, but is not quite so contrasty as the Background-X. Dupont "Quarter speed" film has been used with success, but has perhaps a little too much contrast. Kodachrome can be used successfully, but color values may be slightly, though not seriously, distorted by the greenish tinge of the plane window.

Exposure:

The exposure should be such as will permit full development so as to obtain maximum contrast. The exposure will, of course, depend on the film used, and on light conditions. On an ordinary sunny day in the United States, using Background-X or Panatomic-X film and a light yellow (K-2) filter, a speed of f-6.3 and 1-100 second is perhaps average. The proper timing can best be obtained by testing the film from a high point of ground before the flight, recording light meter readings, making several exposures both longer and shorter than those called for by the light meter, checking the results after development, and choosing the factor which gives best results.

Unless the plane is flying close to the ground, its motion relative to the ground does not necessitate a rapid shutter speed. At heights of 2,000 feet or more, speeds as low as 1/40 or 1/30 second will give satisfactory results, although of course, if light conditions permit, shorter exposures are desirable. The principal cause of blurring is not the plane's speed relative to the ground, but motion of the plane if the air is rough. In smooth air, no trouble is encountered, but in rough air short exposures are necessary and even then it is difficult to avoid blurring. With a camera having a focal plane shutter, exposures less than 1/100 second can be used, but they give uneven lighting across the film. Apparently there is an inertia lag in the shutter which results in one side of the film being exposed more than the other. A similar uneven exposure results when a picture is taken with the sun approximately either in front or behind the plane, because on the half of the picture toward the sun the haze or dust particles do not reflect light into the lens and consequently do not affect the illumination, but on the side away from the sun such reflection noticeably increases the light intensity. This effect, of course, depends on atmospheric haze, and is at a minimum on exceptionally clear days. It can be compensated by "dodging" during enlargement. On account of atmospheric haze, a filter is necessary for all pictures except those taken steeply down at relatively low altitudes. The writer has used the light yellow K-2 filter, but is not certain that this gives the best results under hazy conditions.

Development:

Development should be such as to give strong contrast and at the same time as fine grain as possible. Compared with ground photography, there should be a tendency toward under exposure and over development for the sake of contrast. The Eastman D-76 formula has given best results.

Stereoscopic pictures:

With a miniature camera permitting exposures in rapid succession, it is entirely practicable and for some types of work very advantageous to take oblique steresocopic pictures. The essential requirement is only that the two pictures composing the steresocopic pair be taken in as rapid succession as possible with the camera pointed at the same objects. For any geographic work in which it may be desirable to study relief features, stereoscopic pictures are especially useful.

LOCATING THE PICTURES ON THE MAP AFTER FLIGHT

Having obtained during flight the time when each picture was taken and the time when the plane passed over known objects or control points at intervals of 15 to 30 minutes, the procedure for locating the pictures on the map is to draw the flight lines as straight lines between control points on a base map of suitable scale, and then to obtain the location of each picture along these lines in porportion to time and distance. A slide-rule is extremely useful for this purpose. This procedure assumes uniform speed and straight line flight between control points. In a region for which detailed topographic maps are not available, locations so made must be accepted as final unless the observer at the time has made notes as to deviations from straight-line flight which may have occurred, or unless features shown on the pictures permit more definite location. Deviations from a straight course are rare, however, in ordinary scheduled flight, and locations so made will ordinarily be correct within a mile or two. Even in the rather featureless sand hills of western Oklahoma, the sites of pictures so located have been found without difficulty on the ground.

If a detailed topographic map is available, the location of the pictures can then be determined exactly because the locations on the smaller-scale map, made as above described, will be close enough so that on the detailed topographic map objects shown in the pictures can readily be found. It is then possible to make any necessary corrections in the line of flight and in the location of the pictures along it.

ADVANTAGES OF THE AERIAL TRAVERSE IN GEOGRAPHIC STUDY

By the methods above described it is possible by flight over a region on a clear day to make a photographic record of geographic features along the route with sufficient detail so that all significant changes in topography or culture may be recorded, as well as typical examples of each. The result is an essentially complete photographic record in traverse form. Such a record seems to have great possibilities for usefulness because the photographs tell the story much more vividly than it can be told in words.

EXAMPLES OF THE METHOD AS APPLIED TO OHIO AND THE PANHANDLE REGION OF TEXAS

The accompanying pictures are introduced to illustrate the types of geographical information obtainable by the methods described. The first eight pictures illustrate typical aspects of Ohio geography.

Figure 1 may be taken as representative of the Wisconsin glacial till plain. The ground is almost perfectly flat, drainage is as yet unorganized, and the soil shows the characteristic mottling of light and dark, in which the darker areas represent the black soil on the lower ground. Such glacial plains constitute the rich agricultural land of much of Ohio, Indiana, Illinois, Wisconsin, and Iowa. Interesting details in this picture are a trunk highway crossing the center of the picture; a field of wheat in shock lying beyond the highway at the left; and a field of uncut wheat that may be recognized on the near side of the highway at the right by the lines of oval dark spots which represent the positions where corn shocks stood the preceding autumn when the wheat was planted.

Figure 2 shows a typical aspect of the Illinoian glacial till plain about two miles northeast of Georgetown, Brown County, which appears at the upper right of the picture. Clearly this plain has been exposed to erosion much longer than the Wisconsin plain of Fig. 1 because stream drainage has here developed to an early mature stage. A well organized dendritic drainage system may be seen in the lower half of the picture, but in the upper half the original flatness of the till plain has not yet been destroyed. In the lower half of the picture the ravages of soil erosion can be clearly recognized in the white bands bordering each of the minor tributary valleys.

Figure 3 illustrates a typical floodplain—that of Scioto River immediately north of Piketon, Pike County (between Piketon and Waverly). The river, crossed by a bridge, appears in the foreground. In the upper right half of the picture is a large meander which has recently been cut off, and on either side of the floodplain the wooded hills may be recognized. The picture is interesting primarily because it shows one of the commonest features of floodplains as they appear from the air, namely the "tracks," represented by curved bands of light soil, of ancient meanders showing successive periods of their growth and abandonment.

Figure 4 showing the floodplain of Scioto River immediately northwest of Portsmouth, Ohio, represents an even more striking development of floodplain features. Scioto River crosses the lower left and the Ohio the upper left corner of the picture. Many abandoned meanders can be seen, some of them still containing oxbow lakes, as at the upper left, and others made visible only by variations in the color of the soil. Some of these ancient meanders and former ox-bow lakes, though plainly visible, are so nearly obliterated topographically that, as shown near the center of the picture, the farmers plough across them without deviation. The border of the floodplain is followed by a highway, beyond which are the wooded hills. A suburb of Portsmouth (Bertha) appears at the right center.

Figure 5 shows an interesting development of orcharding on the floodplain and low terrace on the Ohio side of the Ohio River, about seven miles east-northeast of Huntington, West Virginia. The bluffs bordering the terrace appear at the lower right. Extensive orchards may be readily recognized by their distinctive pattern. Soil differences resulting from meander growth of the Ohio may be detected by color changes and seem to have been reflected in property ownership, as indicated by the pattern of the fields.

Figure 6 portrays a typical example of the unglaciated portion of eastern Ohio. Erosion of the region, whose relief is about 300 feet, has passed somewhat beyond maturity. Cleared farmlands are divided almost equally between upland divides and valley bottoms. About one-third of the area is wooded—mainly on the steeper valley sides.

Figure 7. In the maturely dissected, unglaciated Alleghany plateau, soil erosion is serious. One of the most effective means of combatting erosion is "strip cropping," of which a particularly fine example is here shown. Strips of ground contouring the hills are planted with different crops in such a way that a crop, such as corn, that promotes erosion alternates with another like alfalfa, that holds the soil in place.

In the center of the picture the corn shocks on three of the strips are readily recognized. The darker strips are probably grass or alfalfa, and the lighter probably wheat.

Strip cropping is not yet extensively used in the plateau, but a few fields so cultivated may be seen in almost every neighborhood (see Fig. 6 near center) and soil conservation agencies are urging its wider adoption.

Figure 8. A type of mining that is extensively developed in eastern Ohio—the strip mining of coal—is strikingly revealed from the air.

In strip mining, which requires that the coal bed lie close to the surface over considerable areas, the overburden of soil or rock is removed by power shovels which strip it from above the coal and swing it to one side where it is piled in great wind-rows, such as are shown on the photograph. In this area an overburden of nearly 50 feet has been removed to recover a bed of coal 30 inches thick. The aftermath of strip mining, as is well illustrated on the picture, is almost complete devastation of the area mined. Rehabilitation of the land ruined by strip mining is one of the problems confronting the State. For agriculture, the land is probably permanently ruined, but certain types of forestry offer possibilities for rehabilitation.

By way of contrast to Ohio, two photographs are introduced illustrating a totally different geographical environment—the Panhandle region of Texas.

Figure 9 illustrates the sand hills which border the Canadian River, a short distance north of the village of Clear Creek, Hemphill County, Texas. A railroad crossing the lower right corner of the picture serves as scale. Sand has been blown for several miles to the east, from the usually nearly dry bed of Canadian River and piled into low, irregular dunes, such as those shown on the photograph. Most of this sand appears now to be stationary, as is evidenced by its partial vegetation cover, and only occasionally do active "blow-outs" testify to present movement of the sand. This condition suggests a more arid climate at the time these sand hills were formed.

Figure 10, taken late in the afternoon along Red Deer Creek, about five miles northwest of Miami, Roberts County, Texas, is a beautiful study of erosion working headward from one of the larger streams into the grassy plains of the Texas Panhandle. Scale is indicated by a railroad which crosses the picture beyond the sandy bed of the "river."

Fig. 1 (upper). Till plain of the Wisconsin glaciation, with characteristic soil mottling. Looking north. Center of picture 39° 47.5′ N., 83° 13.6′ W., 12½ miles west of Columbus, Ohio.

Fig. 2 (lower). Till plain of Illinoian glaciation northeast of Georgetown, Ohio. Center—38° 52.6′ N., 83° 52.7′ W. Looking southwest.

Fig. 3 (upper). Floodplain of Scioto River south of Waverly, Ohio. Looking north. Center—39° 5.5′ N., 83° 00.5′ W.

Fig. 4 (lower). Floodplain of Scioto River near its junction with Ohio River. Looking south. Center—38° 44.9′ N., 83° 1.0′ W.

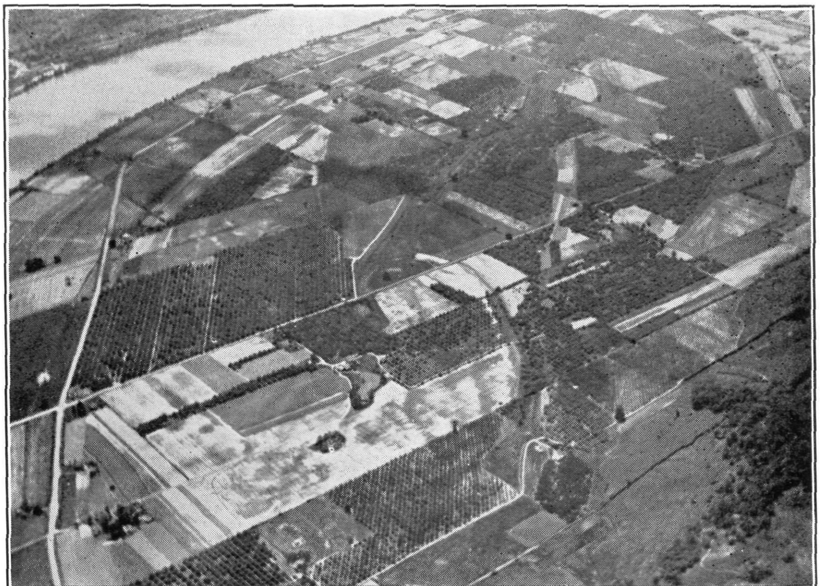

Fig. 5 (upper). Orcharding on floodplain and terrace of Ohio River about 7 miles east-northeast of Huntington, W. Va. Looking southwesterly. Center—38° 27.5′ N., 81° 20.5′ W.

Fig. 6 (lower). Typical unglaciated plateau of eastern Ohio 1¼ miles southwest of Freeport, Harrison County. Looking north. Center—40° 2.5′ N., 81° 17.1′ W.

Fig. 7. Strip cropping to control soil erosion on the unglaciated Allegheny plateau. Looking north about 3 miles northwest of Avella, Pa., about one mile east of the West Virginia line. Center—40° 18′ N., 80° 30′ W.

Fig. 8 (upper). Strip mining for coal in eastern Ohio. Looking northeast at large mine four miles south of Dresden, Muskingum County. Center—40° 4.1′ N., 82° 2′ W.

Fig. 9 (lower). Sand hills along east side of Canadian River north of Clear Creek, Hemphill Co., Texas. Looking northerly from 35° 57′ N., 100° 15.3′ W.

Fig. 10. Study in erosion along Red Deer Creek, Roberts County, Texas, about five miles northwest of Miami. Looking southerly from 35° 43′ N., 100° 43′ W.